# Combining AIRS and TES CO Measurements

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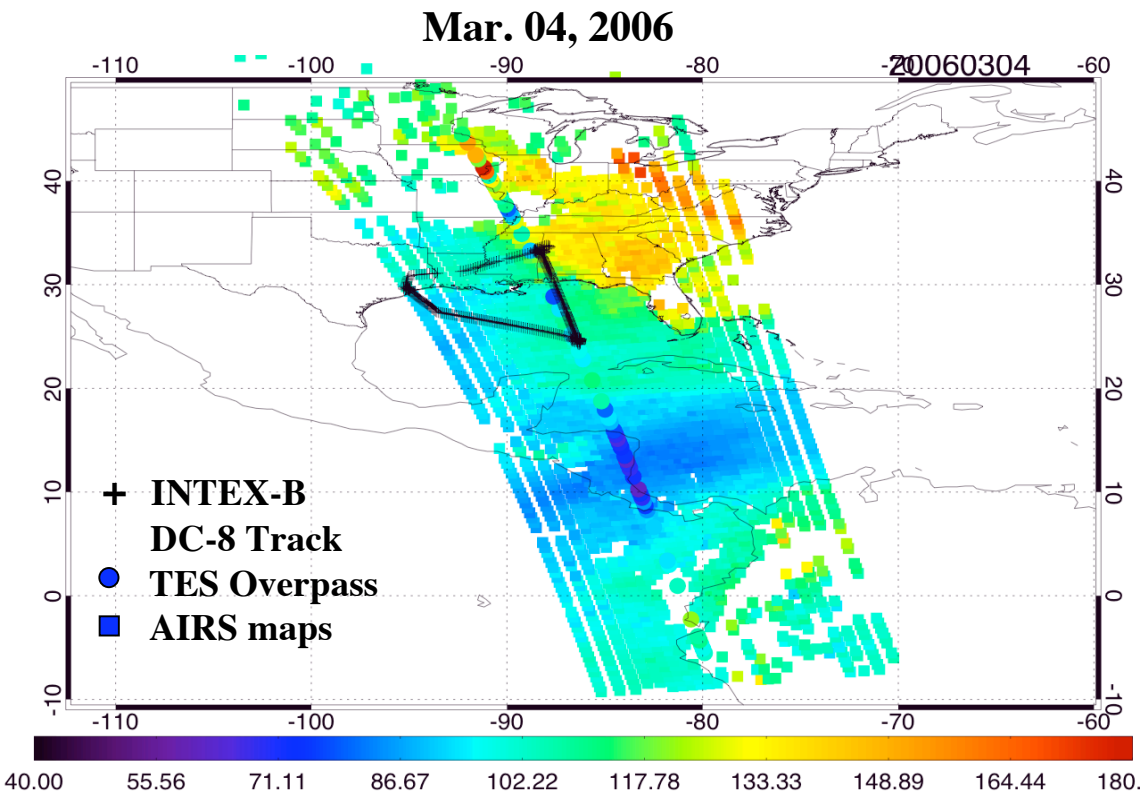
## Background

- Intercomparison of AIRS CO with MOPITT (Warner *et al.*, 2007, *JGR*) and with TES (Warner *et al.,* in review, *GRL*) has been published and/or presented.

- Intercomparison work funded by NASA grants: Aura Validation (PI-Warner 6/06-5/09) and ROSES05 AC (PI-Warner 7/07-07/10).

- Trace gas retrievals are biased by the selection of *apriori* or first guess. When the observed information is low, the retrievals are strongly affected by the *apriori*.

- The differences in sensitivities and information content in different instrument can be compensating.



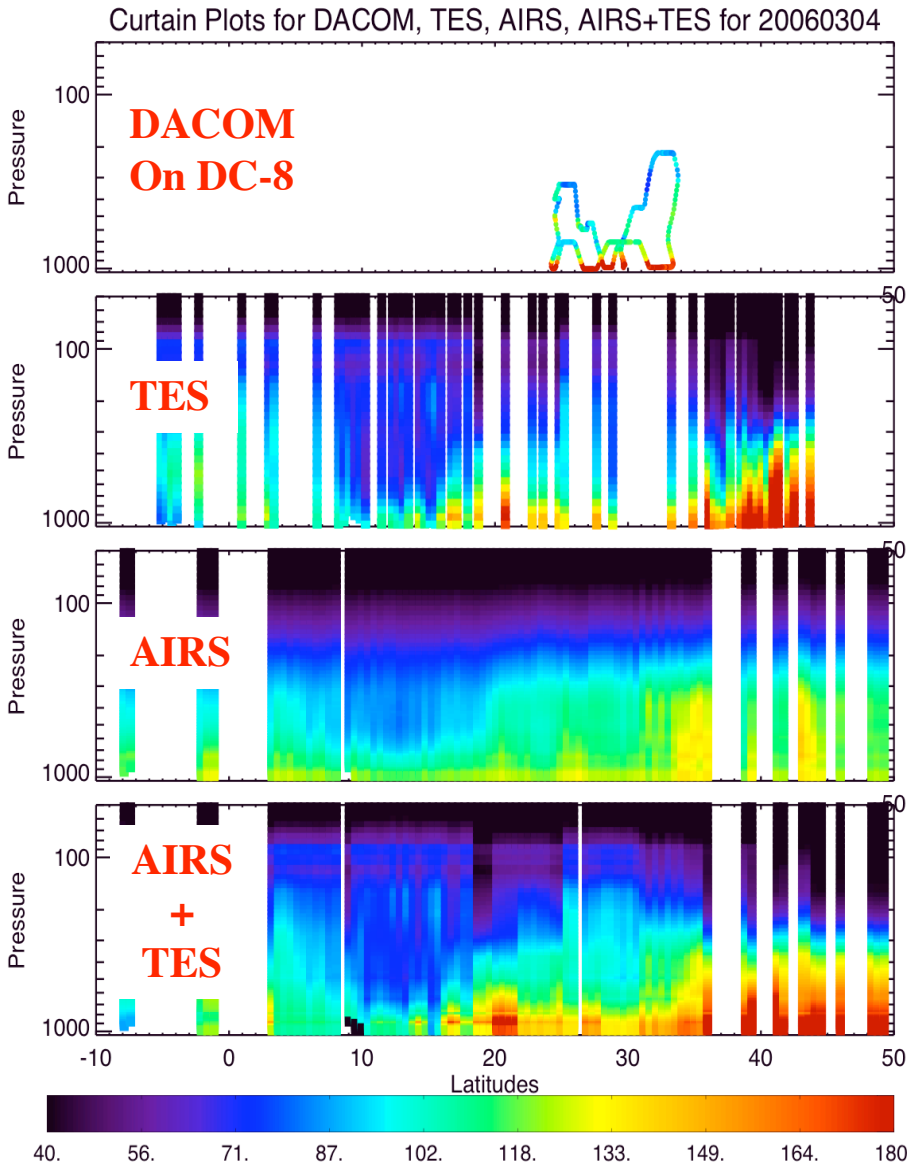

- AIRS and TES, on A-train, take CO and $O_3$ measurements within 15min of each other. AIRS coverage is higher due to wide swaths and cloud clearing. TES provide higher sensitivity and more information in the lower troposphere due to its higher spectral resolution.
- Under nadir AIRS and TES are collocated TES L2 profiles are used as apriori in AIRS retrievals.
- TES profiles are populated to AIRS space where they are not collocated using Objective Analysis method to produce a post-processed apriori field.
- Re-process AIRS retrieval using the new apriori field.

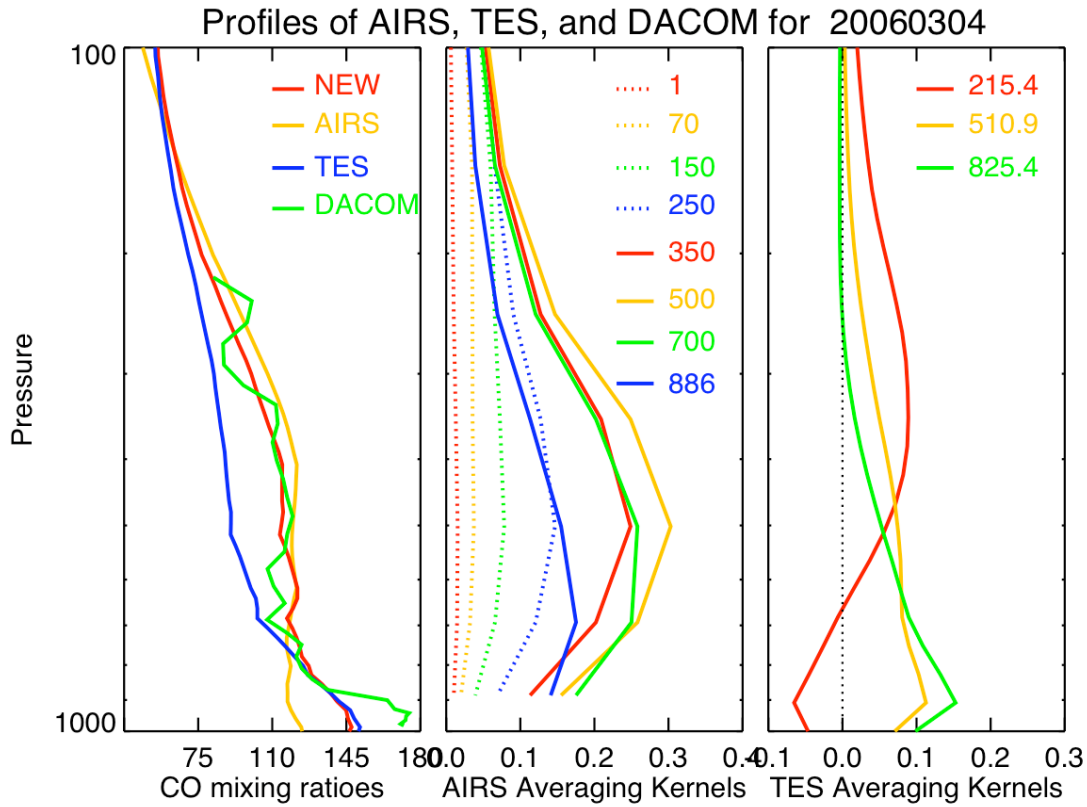
• Using TES L2 profiles in AIRS retrievals increase lower tropospheric information compared with using AIRS alone, which is especially important for air quality monitoring.

• This increased information in the lower troposphere, as shown in the right bottom panel compared with the 3rd panel, will be populated onto AIRS coverage.

• Higher CO in the lower troposphere is due to the fire activities over the south-east US.

• AIRS v5 CO may contain more lower trop info than display here, using TES should still improve retrievals nonetheless.





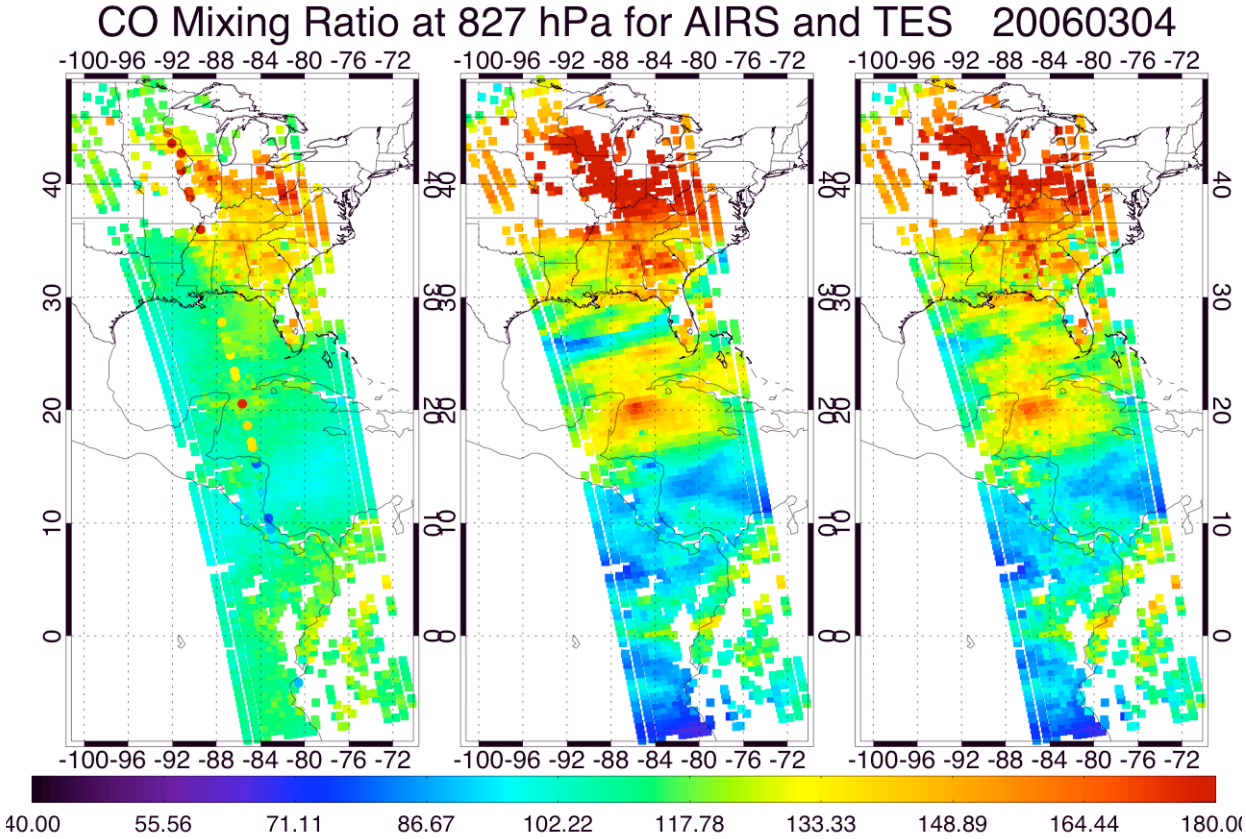

- Combined AIRS and TES CO agree better with in situ throughout troposphere.
- Below 900mb, sensitivities for both sensors decrease significantly.

# Data Assimilation Algorithm (for each pressure level)

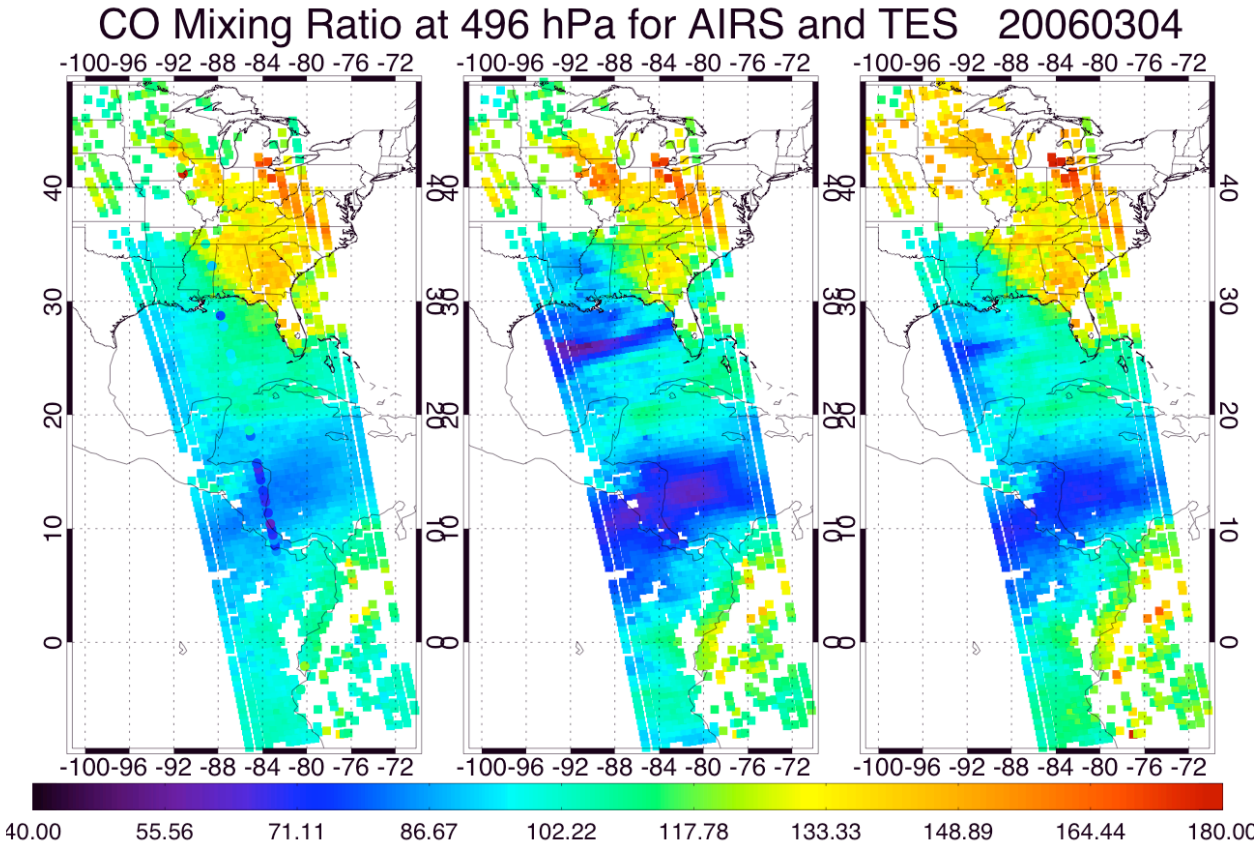
- AIRS Data Set (background): $\mathbf{x}^b$
- TES Data Set (observation): $\mathbf{y}$
- Gain matrix: $\mathbf{K}$
- Background Error Covariance (synthetic): $\mathbf{P}^b$
- Observation Error Covariance (synthetic): $\mathbf{R}$
- Observational Operator: $\mathbf{H}$
- Analysis State (assimilation output / *apriori* input):

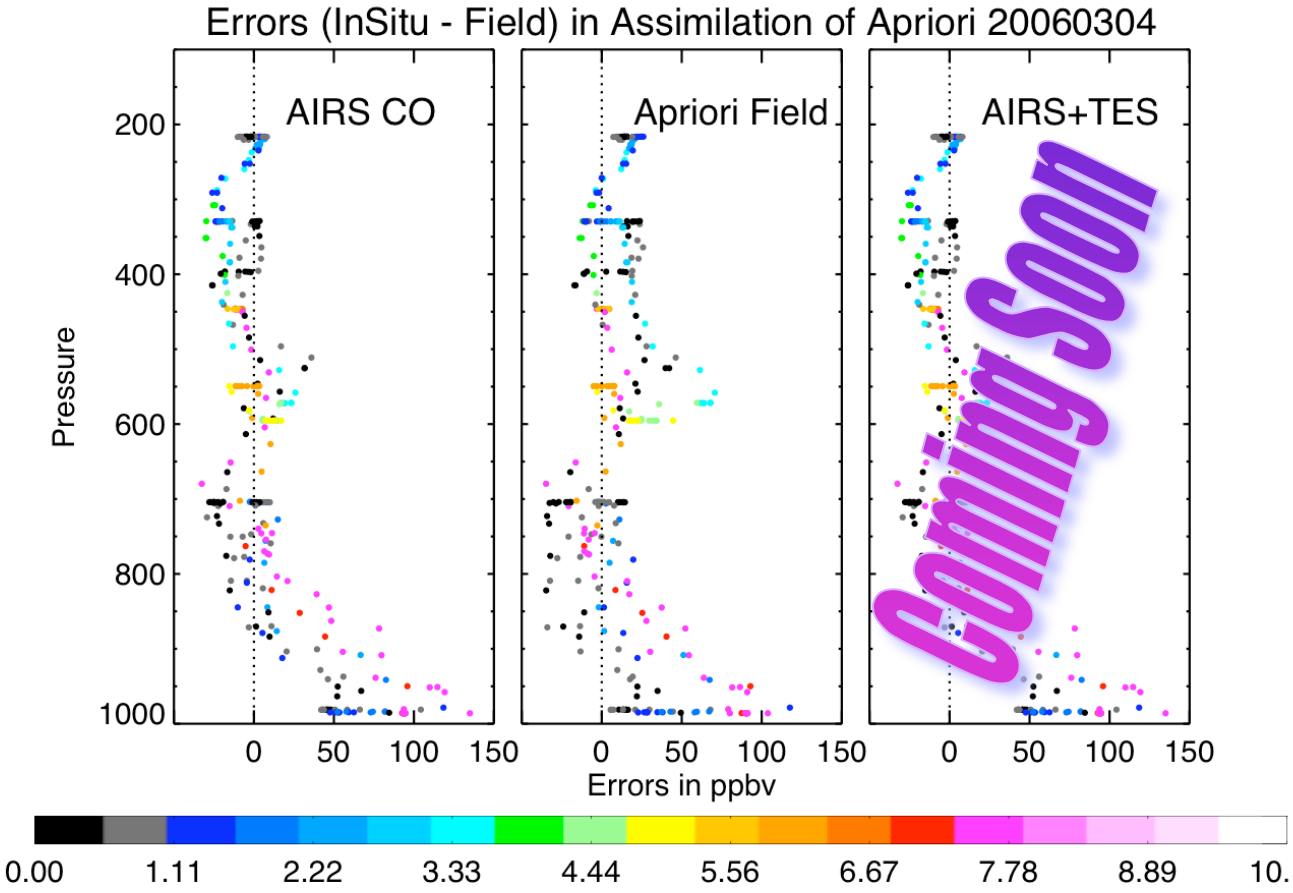
$$\mathbf{x}^a = \mathbf{x}^b + \mathbf{K}(\mathbf{y} - \mathbf{H}\mathbf{x}^b)$$

$$\mathbf{K} = \mathbf{P}^b\mathbf{H}^T(\mathbf{H}\mathbf{P}^b\mathbf{H}^T + \mathbf{R})^{-1}$$




- TES lower troposphere information is propagated using AIRS variance.
- Full “assimilation” scheme with proper retrieval error covariances is needed to develop the post-processed *apriori*.
- The combined CO shows better agreement with TES and DACOM.


CO Mixing Ratio at 496 hPa for AIRS and TES 20060304
-100 -96 -92 -88 -84 -80 -76 -72
40
30
20
10
0
40.00
55.56
71.11
86.67
102.22
117.78
133.33
148.89
164.44
180.00


Errors (InSitu - Field) in Assimilation of Apriori 20060304
AIRS CO
Apriori Field
AIRS+TES
Coming Soon
Pressure
200
400
600
800
1000
0
50
100
150
Errors in ppbv
0.00
1.11
2.22
3.33
4.44
5.56
6.67
7.78
8.89
10.

# Summary and Future Work

• Combining AIRS and TES increases lower tropospheric CO information compared with AIRS, and
• increases coverage compared with TES.

• Future work involves increased accuracy of the post-processed *apriori* field by including proper error covariance matrices from the satellite retrievals.
• Including other datasets such as MLS CO, etc.
• Testing this technique on AIRS optimal estimation retrievals, which is funded and under development.